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British Standards Institution Report

(Superseding No. 49 on 1st December, 1919.)

No. 89—1919.

British Engineering Standards Association.

(Incorporated 1918.)

FORMED IN 1901 AS THE ENGINEERING STANDARDS COMMITTEE

BY

THE INSTITUTION OF CIVIL ENGINEERS.
THE INSTITUTION OF MECHANICAL ENGINEERS.
THE INSTITUTION OF NAVAL ARCHITECTS.
THE IRON AND STEEL INSTITUTE.
THE INSTITUTION OF ELECTRICAL ENGINEERS.

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BRITISH STANDARD SPECIFICATION

FOR

INDICATING AMMETERS, VOLTMETERS, WATTMETERS, FREQUENCY AND POWER-FACTOR METERS.

LONDON

PUBLISHED FOR THE ASSOCIATION BY CROSBY LOCKWOOD & SON,
7, STATIONERS' HALL COURT, LUDGATE HILL, E.C.4; AND 5, BROADWAY, LONDON, S.W.1;
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PREFACE.

The revision of this Specification was commenced July, 1915, and the Panel appointed for the purpose submitted a recommendation to the Sub-Committee on Electrical Accessories that in carrying out this revision the Specification should be extended to deal with wattmeters, power factor and frequency meters, and to include both indicating and graphically recording instruments.

This proposal was agreed to and the Panel found it necessary to draft two Specifications, one dealing with indicating and the other with recording instruments. The Specifications, therefore, are much more than a revision of the Report No. 49.

The question of the degree of accuracy which should be called for in the Specification involved long discussion during the preparation of the first report, and the same question has again been discussed at considerable length.

It is argued on the one hand that the object of a Standard Specification is to secure generally the highest possible quality in the manufacture of the apparatus dealt with, and this school of thought considers questions of cost as secondary matters. The opposing party urges that the object of a Specification is to define the minimum standard of quality which must be attained if the apparatus is to perform satisfactorily the functions for which it is intended, and that nothing higher than this minimum should be required by the Specifications, if industry is not to be hampered by unnecessary cost of production.

The Clause dealing with limits of accuracy in this Specification is the result of a compromise between these two points of view. While intended to secure a degree of accuracy adequate for the purposes indicating instruments are usually required to serve, it must not be interpreted as signifying that, in the opinion of the Panel, indicating instruments cannot be made to read within closer limits than those laid down.

C. H. WORDINGHAM,

Chairman of Sub-Committee on Electrical Accessories.

NOTE.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the article herein referred to, but does not purport to comprise all the necessary provisions of a Contract.*

BRITISH STANDARD SPECIFICATION FOR INDICATING AMMETERS, VOLTMETERS, WATTMETERS, FREQUENCY METERS AND POWER-FACTOR METERS.

DEFINITIONS.

Instrument.

1. The term "instrument" denotes an indicating ammeter, voltmeter, wattmeter, power-factor meter or frequency meter, and the terms "instrument," "ammeter," "voltmeter," etc., include the indicator (as defined below) together with any accessory apparatus such as shunts, connecting wires, transformers, inductances, condensers or resistances even if separated from the indicator.

Indicator.

2. The term "indicator" denotes the instrument proper and includes essentially the means for producing the operating forces, the movement, the pointer, the dial and the case containing them. It excludes any accessory apparatus such as shunts, transformers, condensers, inductances or resistances, whether contained in the indicator case or otherwise.

Self-contained Instrument.

3. The term "self-contained instrument" denotes one in which all accessory apparatus, that is necessary to cause the scale figuring to correspond with the numerical value of the quantity measured, is enclosed within or permanently attached to the indicator case.

Effective Range.

4. The term "effective range" denotes :—

(*a*) In an ammeter, voltmeter or wattmeter, the scale of which is one of nearly equal parts from zero upwards, that portion of the scale which extends down to and includes one-tenth of the maximum scale value.

(*b*) In an ammeter, voltmeter or wattmeter, the scale of which is greatly contracted in the neighbourhood of zero, that portion which extends down to and includes one-quarter of the maximum scale value, but it includes the maximum scale value, even when the higher divisions are contracted as compared with the central ones.

(*c*) In a voltmeter, the scale of which is partially suppressed, the whole range of the instrument.

Ordinary Frequency.

5. The term "ordinary frequency" denotes, for the purposes of this Specification, any frequency between 25 and 100 periods per second, both inclusive.

Length of Scale.

6. The term "length of scale," used in connection with an indicator, denotes the distance traversed by the tip of the pointer in passing from one end of the scale to the other.

Scale Mark.

7. The term "scale mark" denotes the line indicating the value of the quantity measured.

Scale Division.

8. The term "scale division" denotes the interval between the centres of successive scale marks.

Long Scale Mark.

9. The term "long scale mark" (*see* A, Figure 1, page 10) denotes that which is extended beyond the length of the normal scale mark to assist in the rapid appreciation of the value of the indication.

Normal Scale Mark.

10. The term "normal scale mark" (*see* B, Figure 1, page 10) denotes that which forms the primary divisions between the long scale marks.

Short Scale Mark.

11. The term "short scale mark" (*see* C, Figure 2, page 11) denotes that which subdivides the primary divisions.

Middle Point.

12. The term "middle point" of a scale denotes half the maximum scale value. When the zero is in any position other than at the end or the centre of the scale the middle point is half the greater of the two maximum scale values.

Error in the Indication.

13. The term "error in the indication" denotes the difference of the indication referred to from the true value of the quantity of which it purports to be a measure.

STANDARDS.

British Standards of Electrical Quantities.

14. The British Standards for electrical measurement shall be the legal standards in the custody of the Board of Trade, and all electrical quantities referred to in this Specification shall be measured

in terms of these standards, by means of apparatus which is in agreement with such standards at the time of use.

Standard Temperature.

15. The Standard temperature, for the purposes of this Specification, shall be 20° C. (68° F.) unless otherwise marked on the indicator.

SPECIFICATION.

Classification in Degrees of Accuracy.

16. Instruments shall be grouped in three classes, according to the degree of accuracy which they purport to possess. These shall be called "Sub-standard," "First Grade" and "Second Grade," respectively. The provisions of this Specification shall apply to each class of instrument unless otherwise stated.

Construction.

17. The construction of the instrument shall be mechanically sound, suitable to its class and purpose, and shall be such as to give assurance of permanence in the accuracy of the indications.

Continuous Service.

18. The instrument shall be capable of being used continuously at its maximum indication, or in the case of a wattmeter or power factor meter at the marked current and pressure, without injury and without the specified limits of error being exceeded.

Case or other Protection.

19. The indicator shall be contained in a suitable dust-tight case, of sufficient strength to afford adequate protection against injury when reasonably used; and the accessory apparatus shall be suitably protected when necessary to ensure permanence of the accuracy of the indications.

In addition to the foregoing, the following requirements shall apply to special types of protection:—

A case purporting to be *flame-proof* shall withstand, without injury, any explosion of gas that may occur within it, and shall not transmit the explosion to any inflammable gas outside.

A case purporting to be *watertight* shall withstand complete immersion in a tank containing sufficient water to cover all parts to a depth of not less than three feet, and after being immersed for not less than one hour shall not show any trace of the percolation of moisture into the interior.

A case purporting to be *splash-proof* shall be so constructed as to ensure permanence of accuracy of the indications when the instrument is occasionally exposed to external splashing.

Identification of Terminals.

20. The terminals shall be clearly and indelibly marked, when the direction of the current between them is material, to indicate clearly the proper direction of the current through the instrument (*see* Clause 31.)

When an instrument is polarised, the left hand or bottom terminal, as seen from the front of the instrument, shall be the positive terminal.

Direction of Deflection.

21. The direction of the motion of the pointer of an instrument, other than a vertical edgewise instrument, from zero to the maximum deflection, shall be from left to right. When the scale subtends an angle of more than 100 degrees, the motion of the pointer shall be clockwise, with the zero and maximum point near the bottom.

The direction of motion of the pointer of a vertical edgewise instrument shall be from bottom to top unless otherwise specified by the purchaser.

In the case of an instrument having a displaced zero, the maximum deflection referred to is the deflection obtained when the current is passing through the instrument in accordance with the terminal marking required by Clause 20.

Scales.

22. (*a*) *Value of Divisions.*—The value of each scale division shall be either 1, 2 or 5 of the units measured, or any decimal multiple or sub-multiple of these numbers.

(*b*) *Width of Divisions.*—For all Sub-Standard instruments and First Grade portable instruments the angle subtended by a scale division shall be not less than 0.5 degree. For all First Grade and Second Grade instruments, other than those of the portable type, the angle subtended by a scale division shall be not less than 1.0 degree.

(*c*) *Construction of Scale.*—The scale shall be divided throughout its effective range and consistently with the requirements of section (*b*) of this Clause, with scale marks arranged in accordance with one of the two systems illustrated in figures 1 and 2 (*see also* Appendix I.).

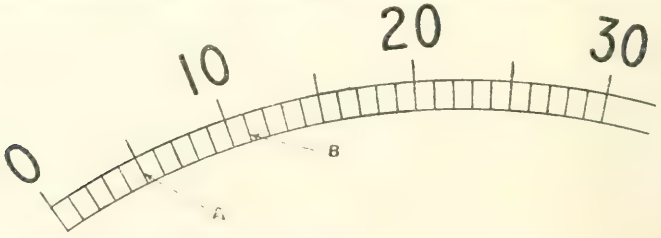


Figure 1.

Figure 1 shows a scale formed of the necessary number of groups of marks, each group consisting of a long mark followed by

four normal marks, with a long mark at the end. Scales of this type shall only be used for indicators in which the scale divisions represent 1 or 2 of the units measured, or decimal multiples or sub-multiples of these numbers.

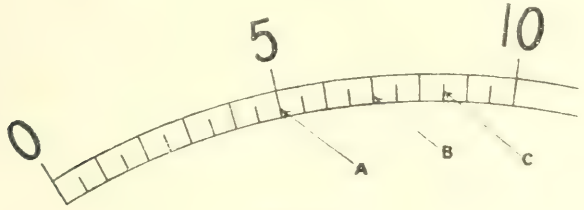


Figure 2.

Figure 2 shows a scale in which a short mark sub-divides each of the scale divisions of figure 1 ; thus forming a series of groups of ten divisions followed by a long mark at the end. Scales of this type shall only be used for indicators in which the scale divisions represent five of the units measured, or a decimal multiple or sub-multiple of 5.

(*d*) *Figuring.*—The figuring of the scale, except in the early part of a non-uniform scale, shall be by steps of 1, 2 or 5, or a decimal multiple or sub-multiple of any of these.

The figures shall be of such shape as to minimise the risk of different figures being confused with one another, and shall be so spaced as to render individual groups clearly distinguishable from adjacent groups.

In the case of scales subtending an angle of not more than 100 degrees the figures shall be disposed symmetrically and similarly throughout the scale marks to which they refer.

Scales of the type shown in figure 2 shall be figured at every long mark or at every alternate long mark.

Normal and short scale marks shall in no case be figured.

Scales of the type shown in figure 1 should usually be figured at every alternate long mark, but may be figured at every long mark if the divisions represent 2 units (or a decimal multiple or sub-multiple of 2), and the figures are of such a size that the requirements of the preceding paragraph of this Clause are complied with. They may also be figured at every long mark when the value of the divisions is 1 (or a decimal multiple or sub-multiple of 1) if in the absence of such figuring there would be less than one group for every 30 degrees of scale.

(*e*) *Suppressed Scales.*—In the case of an instrument with a partially suppressed scale, the suppressed portion of the scale shall be not more than seven-tenths of the maximum scale value.

(*f*) *Scales of Edgewise Instruments.*—The scale of a vertical edgewise instrument shall not subtend an angle greater than 80 degrees.

(g) *Scales of Instruments having more than one range.*—When the indications of an ammeter or voltmeter have to be multiplied or divided by a factor in order that the value of the quantity measured may be correctly deduced from the indication, the scale shall be divided in accordance with the system shown in figure 1 Clause 22; and the factors shall be 1, 2 or 5, or any decimal multiples or sub-multiples of these numbers. The same requirements shall, when possible, be complied with in the case of a wattmeter.

Maximum Scale Value of Ammeter Indicator for use with Transformer.

23 The maximum scale value of an ammeter indicator for use with a transformer shall be 20 per cent. to 33⅓ per cent. in excess of the rated primary current of the transformer.

Maximum Scale Values of Wattmeters of First Grade or Second Grade.

24. The maximum scale value of a wattmeter of First Grade or Second Grade shall be the product of the marked current and pressure, both for direct and for alternating current, unless otherwise specified.

Pointer.

25. The pointer shall be insulated from the electric circuit of the indicator unless the scale plate and stops are insulated from the case; it shall be as light and rigid as possible, and shall be so shaped as to lend itself to ease and accuracy of reading.

If an instrument is not provided with means for avoiding errors of reading due to parallax, the clearance between the portion of the pointer which traverses the scale and the scale itself shall be not more than $\frac{1}{100}$th part of the length of the scale for all instruments having scale lengths of 150 mm. and upwards, and not more than 1·50 mm. for scale lengths less than 150 mm.

In the case of First Grade and Second Grade instruments the pointer shall be of such a length that it extends over more than one-half, but not over more than two-thirds, of the length of the shortest scale mark.

Zero Adjustment.

26. A suitable device, accessible from the outside of the case, shall be provided for adjusting the pointer to zero or other fiducial mark, without risk of damage to any of the working parts of the indicator. This Clause shall only apply to spring controlled Sub-Standard and First Grade instruments.

On circuits carrying pressures exceeding 250 volts, this device shall be such that it can be employed with safety to the operator when the circuit is alive.

Any instrument not complying with these conditions shall bear a warning to the effect that the adjustment shall not be made unless the instrument is entirely disconnected from the circuit.

Damping.

27. The motion of the pointer of every indicator shall be damped sufficiently to cause it to settle to a definite indication within a reasonable time. (*See* Appendix IV.).

Insulation.

28. The instrument shall comply with the following requirements as regards insulation :—

(*a*) The insulation resistance between all the electrical circuits of an instrument coupled together and the containing case, or other metal not intended to be insulated from the case when the instrument is in use, shall be not less than 5 megohms (*see* Clause 25).

(*b*) The insulation resistance between the main circuit and the pressure circuit (if any) shall be not less than 2 megohms.

(*c*) The insulating material between all the electrical circuits coupled together and the case, or other metal not intended to be insulated from the case when the instrument is in use, shall withstand, for one minute, an alternating pressure in accordance with the following table :—

Pressure above earth of the circuit for which the instrument is intended.	Test Pressure (Alternating).
Not exceeding 25 volts ..	250 volts plus twice the working pressure of the circuit.
Exceeding 25 but not exceeding 1000 volts	500 volts plus twice the working pressure of the circuit.
Exceeding 1000 volts ...	1000 volts plus twice the working pressure of the circuit.

For instruments used with current or potential transformers the test pressure shall be 2000 volts (alternating).

If the test be made with direct current the pressure shall be 50 per cent. higher than the value given in the above table.

The insulation resistance shall be measured with a pressure of not less than 200 volts nor more than 500 volts (direct) applied for a sufficient time for the reading of the insulation indicator to become practically steady.

The requirements of (*a*) and (*c*) shall apply to all auxiliary apparatus other than potential and current transformers,* used with the indicator.

Pressure for Permanent Magnet Moving-Coil Ammeter Indicator.

29. When a moving coil indicator is to be used as an ammeter in conjunction with a separate external shunt, the maximum indication shall be obtained when a pressure in accordance with the following table is applied across the ends of a circuit comprising the indicator circuit in series with a resistance of 0.05 ohm, representing the connecting leads of a portable instrument, or 0.025 ohm, representing the connecting leads of a switchboard instrument.

Class of Instrument.	Pressure in volts.
Sub standard	Either 0.0005 or 0.001 per division of the scale of the indicator.
First Grade and Second Grade	0.075

This Clause shall not apply where the indicator is to be used with apparatus connected to the same shunt but requiring some other drop of pressure. In such case, the pressure drop shall be marked on the scale of the indicator.

Marking of Indicator.

30. The following particulars shall be indelibly and distinctly marked on every indicator in a position plainly visible from the front of the case :-

(*a*) Country of origin.

(*b*) The name of the manufacturer.

(*c*) The manufacturer's serial number.

(*d*) The designation of the quantity measured.

(*e*) The words "B.S. Sub-Standard," or "B.S. First Grade," or "B.S. Second Grade."

(*f*) The temperature, if differing from 20°C. (68°F.), at which the conditions as regards accuracy (Clauses 36, 37 and 38) are complied with.

(*g*) The pressure drop, if required (*see* Clause 29).

(*h*) On wattmeters and power factor meters, the maximum current and pressure for which the indicator is intended, except when employed with transformers (*see* (*k*) and (*l*) of this Clause).

* For the pressure test for potential and current transformers *see* British Standard Specification for Instrument Transformers (Report No. 81), when such is issued.

The following additional particulars are required for alternating current instruments:—

(*i*) The frequency, or the limits of frequency, if the accuracy prescribed in Clauses 36 and 37 can only be obtained at this frequency or within these limits of frequency.

(*j*) On frequency meters, the pressure or the limits of pressure at which the accuracy prescribed in Clause 38 can be obtained.

(*k*) On all indicators intended for use with potential transformers, the ratio of the rated primary to the corresponding secondary pressure, expressed thus: $^{6600}/_{110}$.

(*l*) On all indicators intended for use with current transformers, the ratio of the rated primary current to the corresponding secondary current, expressed thus: $^{1000}/_{5}$.

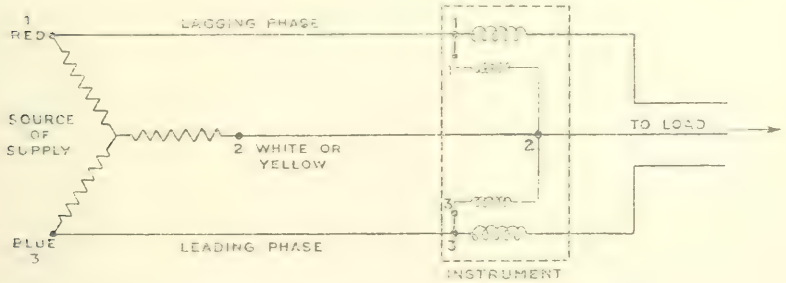
Diagram of Connections and Terminal Marking.

31. A diagram of connections shall be supplied with every wattmeter and power-factor meter, which, in addition to giving the necessary information regarding the connections, shall also show:—

(*a*) The correct disposition of the conductors carrying current to and from the instrument if errors would result from placing them in other than their correct position.

(*b*) For a polyphase instrument, the correct phase sequence of the supply to the windings of the indicator in accordance with the diagram (Figure 3).

For a three-phase two-element wattmeter the terminals shall be marked in accordance with the phase diagram (Figure 3), which shows the convention for connecting a two-element three-phase wattmeter to a three-phase net-work in order to ensure that each element shall have a definite relation to the direction of phase rotation of the system.



THE PRESSURE REACHES A MAXIMUM IN THE PHASES IN THE FOLLOWING SEQUENCE:—1, 2 & 3.

Figure 3.

Correct Indication of Unbalanced Loads.

32. The electrical design of a polyphase instrument complying with the requirements of this Specification may or may not be based on the assumption that the load is symmetrical as regards current or pressure or phase angle, but the class of load for which the instrument is suitable shall be marked thereon.

A polyphase wattmeter purporting to be for use on an unbalanced three-phase circuit shall be provided with at least two current coils connected in different phases, and at least two pressure coils.

A polyphase wattmeter purporting to be for use only on a balanced three-phase circuit need be provided with one current and one pressure coil only.

A polyphase power-factor meter purporting to be for use on an unbalanced load circuit shall be provided with the following coils :—

(i.) When for use on a three- or six-phase circuit, 3 current coils and 3 pressure coils.

(ii.) When for use on a two- or four-phase circuit, 2 current coils and 2 pressure coils.

A polyphase power-factor meter purporting to be for use only on a balanced load circuit shall be provided with the following coils :—

(i.) When for use on a three- or six-phase circuit, either 3 current coils and 1 pressure coil, or 1 current coil and 3 pressure coils.

(ii.) When for use on a two- or four-phase circuit, either 2 current coils and 1 pressure coil, or 1 current coil and 2 pressure coils.

Certificate with Sub-Standard and First Grade Portable Instruments.

33. A certificate shall always be issued with a Sub-Standard instrument, and when called for with a First Grade portable instrument, containing the following particulars :—

(*a*) Date of last calibration.

(*b*) The resistance between the pressure terminals.

(*c*) The information required by Clause 39.

Resistance of Connecting or Shunt Leads.

34. The resistance of the connecting leads employed between a permanent magnet moving-coil ammeter indicator and a separate shunt shall not differ by more than 0.0025 ohm at 20°C. (68° F.) from the nominal value given in Clause 29.

External Shunts.

35. If a shunt is neither enclosed in the same case as the indicator nor structurally a part of the indicator, it shall comply with the following requirements :—

(*a*) The shunt shall have the following particulars indelibly marked either on it or on a label permanently fixed to it.

(i.) The name of the manufacturer or other means by which he can be identified.

(ii.) The manufacturer's serial number.

(iii.) The words "B.S. Sub-Standard" or "B.S. First Grade" or "B.S. Second Grade."

(iv.) The current corresponding with the maximum scale value of the indicator with which it is intended to be used.

(v.) The pressure drop, if it differs from 0.075 volt when the instrument is carrying the marked current.

(*b*) No part of a shunt shall rise in temperature more than 80°C. (176° F.) above the temperature of the surrounding air after carrying the current corresponding to the maximum scale value of the indicator for two hours.

(*c*) The main terminals of the shunt shall be so constructed that slight variations in the method of connecting it to the circuit shall not alter the indication of the instrument by more than 0.25 per cent.

(*d*) The construction of the shunt and connecting leads shall be such that no thermo-electric force is produced sufficient to alter the indication of the instrument by more than 0.25 per cent.

(*e*) The drop in pressure across the terminals of a shunt to which a permanent magnet moving-coil indicator is connected shall be as stated in Clause 29.

(*f*) The drop in pressure across the terminals of a shunt to which an indicator other than one of the permanent magnet moving-coil type is connected shall in no case exceed 1.0 volt, with the maximum indication on the indicator.

Limits of Error in Ammeters, Voltmeters and Wattmeters.

36. The error in the indication of an ammeter, a voltmeter or a wattmeter at unity power factor, when tested over the effective range, at the standard temperature or at the temperature marked on it, and at ordinary frequency or at the frequency marked on it, and, with the exception of a wattmeter, when placed in any position in a magnetic field not greatly exceeding that of the earth, shall not exceed the limits given in the following tables.

In the case of a Sub-Standard instrument, a test for accuracy may be made at any time after application of the pressure, and in the case of First Grade and Second Grade instruments such test shall be made after the pressure has been applied continuously for at least 15 minutes. In instruments provided with a tapping key, the key shall be depressed only for a sufficient time to obtain a reading.

TABLE I. SUB-STANDARD INSTRUMENTS.*

Instrument.	Limits of Error in ammeters, voltmeters and wattmeters. From full scale value to the lower limit of the effective range, expressed as a percentage of the MAXIMUM SCALE VALUE.
	+ or −
Voltmeter, Self-contained ...	0.2
Voltmeter, Indicator of	0.2
Ammeter, Self-contained ...	0.5
Ammeter, Indicator of, permanent magnet moving-coil type ...	0.3
Ammeter, Indicator of, other types	0.5
Wattmeter, Self-contained and indicator of (at unity P.F.) ...	0.5

TABLE II. FIRST GRADE AND SECOND GRADE INSTRUMENTS.*

Instrument.	Limits of Error in ammeters, voltmeters and wattmeters. From full scale value to the middle point, expressed as a percentage of the INDICATION.		From the middle point to the lower limit of the effective range, expressed as a percentage of HALF the maximum scale value.	
	FIRST GRADE.	SECOND GRADE.	FIRST GRADE.	SECOND GRADE.
	+ or −	+ or −	+ or −	+ or −
Voltmeter, Self-contained	1.0	2.0	1.0	2.0
Voltmeter, Indicator of...	1.0	2.0	1.0	2.0
Ammeter, Self-contained	2.0	4.0	2.0	4.0
Ammeter, Indicator of, permanent magnet moving-coil type ...	1.0	2.0	1.0	2.0
Ammeter, Indicator of, other types	2.0	4.0	2.0	4.0
Wattmeter. Self-contained and indicator of (at unity P.F.)	2.5	5.0	2.5	5.0

When the zero mark is at any position on the scale other than at the end, the expression "full scale value" or "maximum scale value" in the above Tables means the sum of the two maxima values.

* *See* Appendix II.

Limits of Error in Power Factor Meters.

37. The limit of error in a power-factor meter, tested at the standard temperature, or at the temperature marked on it, for all currents down to and including $\frac{1}{3}$th of the marked current, at the marked pressure at ordinary frequency, or at the frequency marked on it, shall be ± 2 degrees of angle, between 0.5 and unity power factor.

A variation in the current or the pressure of 10 per cent. up or down from the marked value shall not cause a change in the indication of more than one-half of a degree of angle, between 0.5 and unity power factor.

Limits of Error in Frequency Meters.

38. The limit of error in a frequency meter, when tested at the standard temperature, or at the temperature marked on it, shall be one per cent. of the value of the reading at the middle point of the scale.

A variation in the pressure of 10 per cent. up or down from the marked value shall not cause a change in the indication of more than one scale division.

Variations in the Indications of all Instruments due to changes in the Temperature of the surrounding air.

39. The variation in the indication of an instrument, expressed as a percentage of the indication, due to a variation of 1°C. in the temperature of the surrounding air, shall not exceed the following limits :—

Instrument.	Limits of variation in indication expressed as a percentage of the indication.		
	Sub-Standard.	First Grade.	Second Grade.
	± or −	± or −	± or −
Voltmeter	0.1	0.2	0.4
Ammeter	0.1	0.2	0.4
Wattmeter	0.2	0.3	0.4

Variations in the Indications of Ammeters and Voltmeters due to External Magnetic Fields.

40. The variation in the maximum indication of an ammeter or voltmeter indicator, which is intended to be permanently fixed in any position, shall not exceed 3 per cent. of that indication, when the indicator is exposed to a magnetic field of 10 c.g.s.* units in the direction which produces the maximum error in the instrument readings. For alternating current instruments the disturbing field shall be alternating and in phase with that in the coil of the indicator.

* 800 ampere turns will produce a field of approximately 10 c.g.s. units at or near the centre of a plane circular coil 100 cm. diameter.

Portable First Grade instruments, not purporting to comply with the above requirements, and all Sub-Standard instruments shall bear a statement of the precautions necessary to eliminate or avoid any error due to external fields.

Variations in the Indications of all Alternating Current Instruments due to changes in the Frequency.

41. The variation, at ordinary frequency (Clause 5), in the indication of an instrument (other than a frequency meter) over its effective range, for a departure from the marked frequency, expressed as a percentage of the indication, shall not exceed the following limits :—

Class of Instrument.	Percentage variation in frequency.	Limits of variation in indication expressed as a percentage of the indication.
		+ or −
Sub-Standard	50	0.25
First Grade	5	1.0
Second Grade	5	2.5

NOTE.—In multi-range instruments, in which the lowest volt range is below 110 volts, the figures in the third column above shall be doubled for the same percentage variation in frequency.

Variations in the Indications of Wattmeters due to changes in the Power Factor.

42. The variation in the indication of a wattmeter, over the effective range, for a variation in the power factor of the load from unity to 0.5, expressed as a percentage of the indication, shall not exceed the following limits .—

Class of Instrument.	Limits of variation of indication expressed as a percentage of the indication.
	+ or −
Sub-Standard	0.5
First Grade	2.0
Second Grade	4.0

Limits of Error in the Pressure Drop on Shunts for use with Moving-Coil Permanent Magnet Indicators.

43. In a shunt for use with a moving coil permanent magnet indicator, the drop in pressure produced across the terminals to which the indicator is coupled when in use, shall not differ from

one of those specified in Clause 29, or from that marked on the indicator, by more than the following values when the marked current is passing through the shunt and indicator in parallel.

Class of instrument for which shunt is intended.	Limits of error in the pressure drop expressed as a percentage of the pressure drop.
	+ or −
Sub-Standard	0.2
First Grade	1.0
Second Grade	2.0

Limits of Error in Indicators used with Accessory Apparatus.

44. The limits of error in an instrument comprising an indicator and accessory apparatus (shunts, potential or current transformers, etc.) shall be the sum of the limits permitted for the indicator and the accessory apparatus.

Independent Tests.

45. In the event of any difference between the purchaser (or his representative) and the manufacturer as to the compliance of the instrument with this Specification, either party shall have the right to have the instrument tested by an independent authority to be mutually agreed upon by the parties, or failing agreement by the National Physical Laboratory.

Should the purchaser or manufacturer require that any or all instruments, under a contract, be tested by an independent authority before acceptance, such requirement should form part of the contract.

APPENDIX I.

Scales.—The following is recommended as the ratios of the lengths of the marks on scales :—

Normal marks	...	1.0
Long ,,	...	1.7 to 1.8
Short ,,	...	0.6 to 0.7

It is also recommended that the length of the normal mark should be not less than 0·8 nor more than 1·5 times the distance between the scale marks defining the widest scale division over the effective range.

APPENDIX II.

Accuracy of different Types of Instruments.—It should be observed that it is not always desirable to specify the highest accuracy of which a given type of instrument is capable, since the greater the accuracy demanded the more delicate will be the construction. The capability of an instrument to withstand rough usage and overload will consequently be reduced.

In order to obtain Sub-Standard accuracy, it is generally found necessary to fit to the instrument a knife-edged pointer and means for avoiding parallax. Instruments having Sub-Standard accuracy are generally employed for checking the accuracy of other instruments.

Instruments having First Grade or Second Grade accuracy are generally employed on switchboards. Portable instruments are usually of these degrees of accuracy when a robust instrument is desired and when a Sub-Standard instrument is not essential.

The following tables serve to indicate the class of accuracy which may reasonably be expected :—

(1) With indicating ammeters and voltmeters of various types : —

Type.	Class of accuracy of which capable.	Conditions.
Permanent magnet, moving-coil, portable and laboratory type	Sub-Standard, First Grade or Second Grade.	On direct current.
Other permanent magnet, moving-coil types, including combined ammeter - voltmeter with single movement	First Grade or Second Grade.	On direct current.
Moving-iron ...	First Grade or Second Grade.	On alternating current at or about a given frequency.
Moving-iron ...	Second Grade.	On direct current.
Dynamometer ...	Sub-standard, First Grade or Second Grade.	On direct current or alternating current at ordinary frequency.
Hot-wire	Second Grade.	On direct current or alternating current at ordinary frequency.
Induction ...	Second Grade.	On alternating current at a given frequency and temperature.
Electrostatic— Low Tension ...	First Grade.	On direct or alternating current at ordinary frequency.
High Tension...	Second Grade.	On direct or alternating current at ordinary frequency.

(2) With indicating wattmeters of various types :—

System.	Class of Accuracy of which capable.	Conditions.
Dynamometer ...	Sub-standard, First Grade or Second Grade.	On direct or alternating current at ordinary frequency.
Induction ...	Second Grade.	On alternating current at any given frequency and temperature.

APPENDIX III.

Erecting Shunts.—A shunt dissipates the heat generated when current is passing more by conduction than by radiation. It is, therefore, necessary to ensure that the ends of the shunts, and any bars to which the shunts are connected, are of such section and area as to permit of good contact being made, and thus to prevent any rise in temperature due to insufficient section or bad contact.

When a shunt is built up of a number of sheets, the greatest cooling is obtained when it is erected horizontally with the sheets in a vertical plane, so as to permit the greatest amount of ventilation between the sheets.

If by reason of the design of the switchboard it is necessary to erect the shunt with its terminals one above the other, the lower end of the shunt should be connected to the positive pole.

When the shunt ends consist of flat connecting plates machined either on one or both surfaces, it is essential to ensure that the whole of the surfaces are in contact with the bars to which connection is to be made in order that the lines of flow of current shall be not unduly distorted.

APPENDIX IV.

Damping.—The following table shows what are considered to be the extreme limits of reasonable time for the pointer to settle to a definite reading at the middle point of the scale after being connected to the circuit :—

With a scale not exceeding	$4\frac{1}{2}$	ins. in length,	$2\frac{1}{2}$	seconds.	
,, ,, ,,	7	,,	3	,,	
,, ,, ,,	12	,,	5	,,	

British Engineering Standards Association.

PRICE LIST

OF

BRITISH STANDARD SPECIFICATIONS AND REPORTS.

OCTOBER, 1919.

(This List cancels all previous Lists.)

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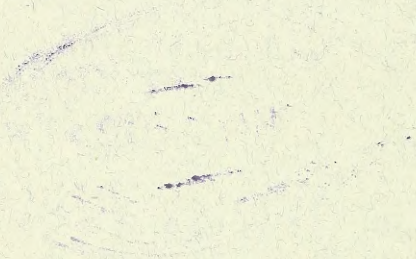
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